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A Fire Effects Appraisal System for Wisconsin

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A FIRE EFFECTS APPRAISAL SYSTEM FOR WISCONSIN

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The rising cost of fire management and the rising value of resources have stimulated concern with appraising the economic effects of wildfire on forest and associated land. Many existing fire effects appraisal systems are limited to estimating economic losses to timber, structures and equipment, and range resources. Appraisal systems are greatly needed that recognize and display the full range of positive and negative fire effects on forest and associated land.

Recent work to establish improved fire effects appraisal systems (e.g., Crosby 1977, Marty and Barney 1981) and to determine the economic efficiency of alternative fire management strategies (e.g., Schweitzer, Anderson and Mills 1982; Simard 1976) have been oriented toward the needs of public land managers. These managers have long term management plans and responsibilities as well as ready access to a good deal of historical, current, and future plan data to provide inputs for evaluations. Appraisal systems designed for these needs are complex, require a lot of data, and consider that value changes resulting from wildfires on public land have an economic impact on the general public over long time periods. The wildfire effects appraisal systems oriented toward public land may not be completely and directly applicable to the immediate needs of individual States that are responsible for fire control and management on private land. The States, especially those in the northeastern United States where most forest land is in small, private ownerships, need to focus on appraisal in terms of economic impact on individual owners in the short term. Few small, private landowners have concrete, long-term management plans for their forests, and few fires in the Northeast have an important impact on the public. Most States are also limited in the amount of time available for wildfire effects appraisal and in the amount of training that can be given to appraisers. The States, therefore, require appraisal systems that are as accurate as possible given time and training constraints, acceptance by field personnel, and the availability of input data. Simplicity and flexibility are crucial for early field acceptance and application. The State systems can then be improved as more complex and theoretically correct systems are refined and tables of expected average value changes for a wide range of fire types, sizes, cover types, and areas are developed over a period of years.

In Wisconsin, wildland fire damage appraisals are frequently used in insurance settlements and legal proceedings. Fire management officials have had legal embarrassments with unsupported values obtained with the previous system, which was developed in 1938. The old system had severe limitations for appraising immature timber stands, particularly plantations. Another problem with the old system is that an arbitrary loss of one dollar per acre was assigned for recreation and wildlife and another dollar loss per acre for site deterioration. In addition, no specific instructions were provided for appraising damage to crops, equipment and improvements, ornamental trees, aesthetics, environmental quality, or developed recreation sites.

Recognizing these shortcomings, the Wisconsin Department of Natural Resources (DNR) formed a "Fire Fuels and Effects Committee" in 1977 to develop an improved system. They enlisted the aid of the North Central Forest Experiment Station, and a cooperative research effort between the Station and the Michigan State University Forestry Department was established to develop an improved system. This report describes that system.

The primary purpose of the new system is to provide accurate wildfire effects appraisal information that would be defensible in court. Certain constraints were imposed by the Committee to ensure a practical system for Wisconsin. The system should be reasonably simple and should take no more than 1 hour to complete for an average fire. It should also make the best possible use of currently existing Wisconsin data.

Researchers reviewed alternative economic approaches and suggested a theoretical framework for each value component of the system. The Wisconsin DNR Fire Fuels and Effects Committee reviewed, and often modified, each value component in terms of their needs for information and the various constraints such as the amount of time and skill available to make appraisals. They were able to see how the system would fit into the existing fire management organization and to evaluate its administrative acceptability. They were also very familiar with Wisconsin resources and the availability of data.

THE FIRE EFFECTS APPRAISAL SYSTEM[1]

Resource Elements

The new system includes the following seven resource elements or value components:

Timber
Wildlife
Recreation
Ornamental Trees
Environmental Quality
Crops
Equipment and Improvements

Recreation is divided into effects on aesthetics and effects on developed recreation sites. Effects on undeveloped recreation are incorporated into the wildlife element. Because the primary purpose of the system is credibility in court, value changes for most of the resource elements are expressed in terms of their impact on individual owners. Value changes for wildlife, aesthetics, and environmental quality, however, are expressed in terms of the impact on the general public because landowners cannot capture all their value.

[1]*A detailed handbook is available from the authors that describes step by step field data collection and office calculation procedures.*

Timber Values

Two methods, the current value and the present net value approach, were considered for appraising fire effects on timber. The present net value approach is the most theoretically correct; but it presents practical difficulties because it requires the prediction of future harvest dates, yields, and prices as well as selection of an appropriate interest rate. In Wisconsin it would also require an increase in field measurements because only diameter class and volume by timber type are presently being recorded, and site index and volume by species are also needed to estimate present net value. Current value, although theoretically less correct than present net value, is simpler to apply because it eliminates the problems associated with predicting harvest date, prices, and yields. If severance tax values are used, field measurements are greatly reduced. The current value method, however, assumes no value for immature timber.

For these reasons we employed a combination of the current value (based on Wisconsin severance tax values) and the present net value methods. Merchantable timber is appraised at current value. The present net value is used for immature timber, but the harvest date is assumed to be the date at which the stand first becomes merchantable rather than the "optimum" rotation age. Using this shorter period reduces both prediction problems and the importance of the choice of discount rate. Salvage value is not considered because it is difficult to determine at the time of the fire, and fire damaged timber is not usually merchantable in Wisconsin.

Losses of merchantable timber are assessed using the following equation:

$$\text{loss} = \begin{matrix}\text{average}\\ \text{volume}\\ \text{per acre}\end{matrix} \times \begin{matrix}\text{average}\\ \text{price by}\\ \text{district}\end{matrix} \times \begin{matrix}\text{predicted}\\ \text{mortality}\end{matrix} \times \begin{matrix}\text{acres}\\ \text{burned}\end{matrix}$$

The procedure for immature timber is the same except that average volume is predicted rather than measured and a 6 percent discount rate is applied. Christmas trees are an exception and are valued by tree rather than by volume.

Regeneration losses and replacement values are calculated only for natural red pine, jack pine less than 7 years old, and white cedar stands with a hardwood understory or with more than 30 percent of the stand in other conifers if more than half of the cedar are killed. All other timber types and conditions will regenerate naturally to the prefire timber type.

The prices used are those calculated annually for timber types by the Wisconsin DNR timber management staff. They are based on the average volume of each species in a particular type for each district. Local stumpage prices for a single species are used only in pure stands, such as plantations.

Predicting tree mortality shortly after a fire is essential to determine timber effects and other value components. Data from Methven (1971) and Loomis (1973), and data collected by the Wisconsin DNR in 1979 were used to develop two linear regression lines for conifers based on percent of crown scorched (fig. 1), and two for hardwoods based on the height of bark scorched (fig. 2). The equations for conifers are:

for $x \leq 57$; $y = 1.386 + 0.401x$; $R^2 = {}^{2}0.66$
for $x > 57$; $y = -75.817 + 1.758x$; $R^2 = {}^{2}0.73$

where y is estimated mortality (percent) and x is the percent of crown scorched. The equations for hardwoods are:

for trees ≤ 5 inches d.b.h.; $y = 49.248 + 4.911x$; $R^2 = {}^{2}0.69$
for trees > 5 inches d.b.h.; $y = 11.861 + 5.070x$; $R^2 = {}^{2}0.75$

where y is estimated mortality (percent) and x is the height of bark scorched.

Wildlife Values

Appraising the physical effects of fire on wildlife is difficult and translating these into economic terms is even more complex. An extremely broad range of possible approaches exists (Shaw and Zube 1980), but no comprehensive and universally accepted system has been developed. Most of the methods considered for Wisconsin attempt to determine the willingness of consumers to buy or sell wildlife-related opportunities. Techniques used to do this include the direct survey, travel cost, market alternative, consumer surplus, opportunity cost, and gross expenditure. The gross expenditure approach was selected for Wisconsin because of the availability of data showing the amount of game harvested by county (Wisconsin DNR n.d.), expenditures and days spent hunting various species (National Analysts 1975), and changes in game populations following fires of different sizes (e.g., McCaffery and Creed 1969). While recognizing that wildlife is valuable for many noneconomic reasons, we assumed that most of the economic value is associated with outdoor recreation,

[2]*For grouped data.*

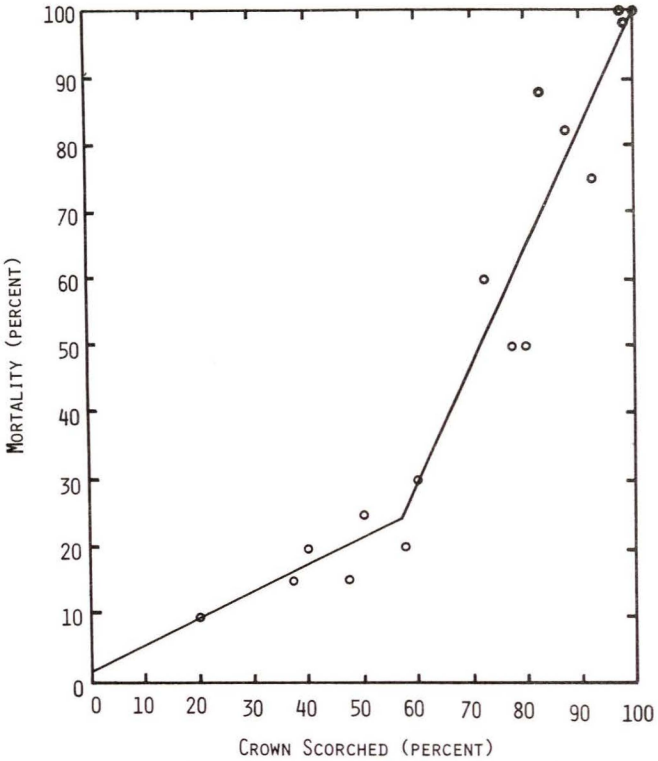

Figure 1.—*Observed conifer mortality and regression line.*

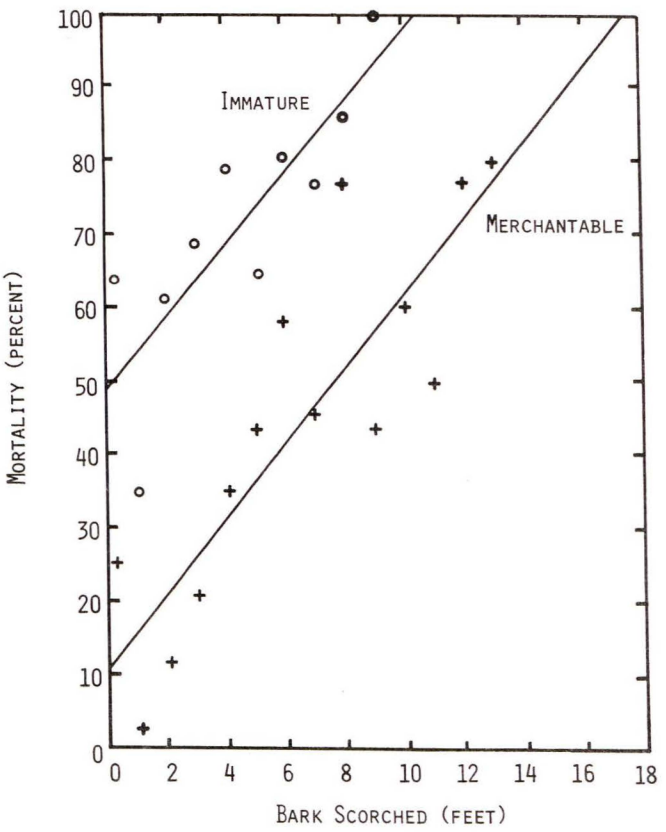

Figure 2.—*Observed hardwood mortality and regression line.*

primarily hunting for game species. This value can be estimated using available figures for the average expenditure per day of hunting each species. A similar figure for expenditures to observe wildlife, including nongame species, is also available. However, pilot tests of the system showed that the observation values affected by fire were negligible and no further attempt was made to estimate them. Fire effects on fish are also assumed to be negligible.

If a fire occurs in a cover type important to deer, small game, or waterfowl, the economic loss and/or benefit are estimated using the basic formula:

$$\text{loss or benefit} = \text{use change} \times \text{wildlife loss or benefit factor.}$$

Use change is a measure of the effective area burned. It is a function of tree mortality and the size of the burned area. Wildlife loss and benefit factors were developed for each county in Wisconsin (table 1). Each factor is the product of the success index for a particular species and county, the average expenditure for a day spent hunting that species, and the full effect of the fire on game populations. The full effect is the change in game population expected if all trees were killed. Generally, the success index is a ratio of use per acre in a county to the average use per acre in Wisconsin. Thus, a success index of one indicates average use, while a two indicates twice the average use. Estimates of the 1980 value of a user day based on hunter expenditures (National Analysts 1975) were $31.82 for deer hunters, $9.61 for small game hunters, and $17.23 for waterfowl hunters.

Benefits to white-tailed deer (in the form of increased browse) accrue when fires occur in white birch and northern hardwood stands or in jack pine and red pine plantations. Losses occur when the fire is in a spruce-fir, black spruce, tamarack, or cedar type.

Fire effects on small game species (rabbit, pheasant, grouse) are primarily beneficial and result from fires in black spruce, white birch, aspen, jack pine, and open fields.

Waterfowl benefit from fires in marshes or open fields within 0.25 miles of water but are harmed if the fire occurs during the nesting season between April 15 and July 31.

Recreation Values

The recreation element includes the effects of wildfires on developed recreation sites and aesthetics. For recreation on developed sites, the same willingness to pay approaches evaluated in the wildlife section were considered and the gross expenditures method was again adopted. The effect of wildfire on developed recreation sites is based on an estimate of the number of visitor groups that would have used the site during the remainder of the season (from time of fire to December 31) and the value per visitor group day for various recreational activities. Determining possible substitution impacts was considered too complex and subjective for practical application. Based on a survey of expenditures in 1969 (Wisconsin DNR 1969) and inflated to 1980 dollars, the values used were:

Sightseeing	$29.74
Camping	28.30
Fishing	26.43
Picnicking	21.64
Boating	17.86
Hiking	17.14
Swimming	12.06

Although no attempt was made to put dollar values on the effects of wildfire on aesthetics, the Wisconsin system provides a consistent procedure to determine the relative impact. Variables influencing the aesthetic effect are the size of the area burned, the aesthetic importance of the area, and the intensity and duration of the effect. Five recreation use classes were identified to rate the relative aesthetic importance of the burned area.

One criterion for selecting the appropriate use class is the type of road from which the burned site can be seen. The highest category is a site visible from a four lane highway while the lowest category is a site that cannot be seen from any road. A second criterion is the general recreational use of an area from which the fire site is visible. Lakes with public access and developed sites such as campgrounds and picnic areas rate the highest category. The lowest category is used for burned areas that cannot be seen from any road, trail, lake, or stream.

The intensity and duration of the fires' effect is measured by determining tree mortality using four arbitrary categories. Aesthetic effects are rated as extreme, very heavy, heavy, moderate, light, or negligible.

Table 1.—*Wildlife loss and benefit factors*

(In dollars/acre)

Region and County	Deer[1]		Small game[2]			Waterfowl[3]	
	Benefit	Loss	SB,BW	A,PJ	Open field	Benefit	Loss
Lake Michigan							
Brown	19.60	11.37	12.49	14.02		6.69	1.11
Calumet	58.80	34.12	12.49	14.02		8.97	1.80
Door	91.87	63.98	1.02	1.99		1.04	.21
Florence	58.80	34.12	.00	1.99		1.04	.21
Kewaunee	91.87	63.98	6.64	16.94		3.60	.67
Manitowac	91.87	63.98	6.64	10.34		6.69	1.11
Marinette	143.34	83.17	6.64	6.94		1.04	.21
Menominee	143.34	83.17	1.02	1.98		3.60	.67
Oconto	143.34	83.17	.00	1.98		3.60	.67
Outagamie	143.34	83.17	12.49	14.02	2.76	3.60	.67
Shawano	143.34	83.17	2.60	6.94		3.60	.67
Waupaca	308.71	214.38	6.64	10.34		3.60	.67
Waushara	308.71	214.38	2.60	6.94		3.60	.67
Winnebago	58.80	34.12	3.79	14.02	12.21	15.52	3.10
Southern							
Columbia	308.71	214.38	2.60	1.98	12.21	15.52	3.10
Dane	58.80	34.12	6.64	10.34	6.99	5.57	1.11
Dodge	19.60	11.37	12.49	14.02	24.67	36.76	7.35
Fond du Lac	58.80	34.12	12.49	14.02	24.67	36.76	7.35
Grant	19.60	11.37	1.02	1.98		3.60	.67
Green	19.60	11.37	12.49	14.02	24.67	1.04	.21
Green Lake	308.71	214.38	6.64	6.94	24.67	36.76	7.35
Iowa	214.39	124.41	1.02	4.35	2.76	3.60	.67
Jefferson	19.60	11.37	6.64	6.94	12.21	36.76	7.38
Lafayette	19.60	11.37	12.49	14.02	12.21	1.04	.21
Marquette	308.71	214.38	1.02	1.98		15.52	3.10
Richland	143.34	83.17	6.64	10.34		1.04	.21
Rock	19.60	11.37	25.47	29.08	24.67	5.57	1.11
Sauk	214.39	124.41	6.64	6.94		3.60	.67
Southeast							
Kenosha	19.60	11.37	25.47	29.08	6.99	5.57	1.11
Ozaukee	19.60	11.37	2.60	1.98	24.67	5.57	1.11
Racine	19.60	11.37	25.47	29.08	6.99	8.97	1.80
Sheboygan	58.80	34.12	6.64	10.34	24.67	5.57	1.11
Walworth	19.60	11.37	25.47	29.08	6.99	5.57	1.11
Washington	58.80	34.12	6.64	4.40	12.21	3.60	.67
Waukesha	19.60	11.37	25.47	29.08	12.21	3.60	.67
Northwest							
Ashland	58.80	34.12	.00	1.98		1.04	.21
Barron	58.80	34.12	1.02	4.35		3.60	.67
Bayfield	91.87	63.98	.00	1.98		1.04	.21
Burnett	143.12	83.17	.00	4.35		5.57	1.11
Douglas	19.60	11.37	.00	4.35		1.04	.21
Iron	19.60	11.37	.00	1.98		1.04	.21
Polk	143.12	83.17	1.02	6.94		3.60	.67
Price	91.87	63.98	.00	1.98		1.04	.21
Rusk	91.87	63.98	1.02	1.98		1.04	.21
Sawyer	58.80	34.12	.00	4.35		1.04	.21
Taylor	58.80	34.12	.00	1.98		1.04	.21
Washburn	91.87	63.98	.00	1.98		1.04	.21

(Table 1 continued on next page)

(Table 1 continued)

Region and County	Deer[1]		Small game[2]			Waterfowl[3]	
	Benefit	Loss	SB,BW	A,PJ	Open field	Benefit	Loss
West Central							
Buffalo	308.71	214.38	1.02	1.98		8.97	1.80
Chippewa	58.80	34.12	1.02	4.35		1.04	.21
Clark	143.12	83.17	1.02	1.98		1.04	.21
Crawford	143.12	83.17	1.02	6.94		15.52	3.10
Dunn	58.80	34.12	1.02	4.35		3.60	.67
Eau Claire	143.12	83.17	1.02	4.35		1.04	.21
Jackson	308.71	214.38	2.60	14.02		1.04	.21
La Crosse	143.12	83.17	2.60	6.94		15.52	3.10
Monroe	143.12	83.17	1.02	4.35		1.04	.21
Pepin	143.12	83.17	2.60	4.35		5.57	1.11
Pierce	58.80	34.12	1.02	4.35		3.60	.67
St. Croix	19.60	11.37	1.02	4.35	6.99	3.60	.67
Trempealeau	214.39	124.41	1.02	6.94		1.04	.21
Vernon	143.12	83.17	2.60	6.94		8.97	1.80
North Central							
Adams	308.71	214.38	6.64	10.34		3.60	.67
Forest	58.80	34.12	.00	10.34		1.04	.21
Juneau	214.39	124.41	1.02	4.35		8.97	1.80
Langlade	91.87	63.98	1.02	1.98		1.04	.21
Lincoln	143.12	83.17	1.02	10.34		1.04	.21
Marathon	143.12	83.17	6.64	10.34		3.60	.67
Oneida	143.12	83.17	.00	4.35		3.60	.67
Portage	214.39	124.41	2.60	10.34		3.60	.67
Vilas	91.87	63.98	.00	6.94		3.60	.67
Wood	308.71	214.38	2.60	6.94		5.57	1.11

[1]Benefits to deer result when fires occur in white birch and northern hardwood stands or in jack pine or red pine plantations. Losses occur when fire is in a spruce-fir, black spruce, tamarack, or cedar type.

[2]Fire effects on small game are beneficial and result from fires in black spruce, white birch, aspen, jack pine, and open fields.

[3]Waterfowl benefit from fires in marshes or open fields within 0.25 miles of water, and losses result if the fire occurs during the nesting season between April 15 and July 31.

Ornamental Tree Values

Many Wisconsin wildfires occur near residences or developed recreation sites where they damage ornamental trees. Selling timber is not the reason for having ornamentals, and it is not appropriate to appraise them on the basis of timber values. Theoretically, the most correct appraisal technique is to estimate property value changes due to ornamental tree losses. However, this would require accurate property appraisals of values prior to and following fires that are beyond the capabilities of field personnel. The method selected assumes that an ornamental tree is lost if the estimated probability of mortality (determined from the mortality graphs) is 50 percent or greater. Small trees and shrubs are appraised at nursery replacement value. The value of each large tree or group of similar trees is estimated using the following formula:

value = base value x species factor x condition factor x location factor.

This formula was developed by the International Shade Tree Conference in 1969 (Michigan Forestry and Park Association 1978). The base value used in Wisconsin is $16.56 per square inch. This is obtained from $9.00 per square inch determined at the International Shade Tree Conference in 1969, inflated to 1980 dollars. The species factors, also developed at the conference, assign each species a factor of 0.25, 0.50, 0.75, or 1.0 according to its desirability as an ornamental. The condition factor is a relative rating, between zero and one, of the prefire health, form, and vigor of the affected tree. The location factor is an assessment of the importance of the ornamental tree in the landscape, ranging from one for a single specimen on a key site to near zero for one of a group of trees at the forest edge of a developed site. All trees must be visible from and within 100 yards of

a lake, home, or developed recreation site to be considered ornamentals.

Environmental Values

Information available in Wisconsin indicates that water quality and soil stability are rarely significantly affected by a single fire. Air quality, however, is affected by smoke, and although no dollar value was assigned, a method to estimate the relative importance of smoke effects on air quality is employed. The method requires determining atmospheric stability (stable or unstable), a smoke index, and a population use class. The smoke index is based both on the size of the fire and the duration of the smoke. Thus a small but long-burning peat fire might produce a higher smoke index than a large grass fire. Five population use classes were identified to rate the importance of use areas affected by the smoke. The classes generally depend on the size of the city or town in which the smoke can be detected, although highway size and recreation use can also influence the classification. The effects are rated as extreme, severe, heavy, moderate, light, or negligible.

Crop Values

The procedure for evaluating the effects of fire on crops and forage is similar to that for timber but simplified by several factors. Most crops are harvested annually, thus eliminating the problem of discounting future values. County agents are generally able to estimate yields and prices. The problem of predicting mortality is also eliminated because crops rarely survive a wildfire. With the new Wisconsin system the loss of a crop is simply the net value of the expected yield except in the unlikely event that the crop can be replanted. If the burned crop can be replanted in the current year, the loss is the sum of the replanting cost and the value of the reduction in the expected yield (the replanted crop would probably have a reduced yield due to a shorter growing season). In either case the following equation can be used:

$$\text{crop loss} = \text{replanting cost} \times \text{acres burned} + \text{yield loss} \times \text{price} \times \text{acres burned}.$$

If a crop cannot be replanted in the current year, the replanting cost is zero.

Equipment and Improvement Values

The method used to appraise damage to equipment and improvements is to estimate the cost to replace the items that are completely destroyed or to restore a damaged item to its prefire condition. In some cases, this will be the additional maintenance required to restore that condition, for example, repainting a barn blackened by smoke.

The field procedures require determination of items that require repair or replacement and an estimate of the prefire condition. The cost of the repair or replacement is determined in the office. Blue books, contractors, and equipment dealers should be consulted.

IMPLEMENTING THE SYSTEM

Pilot Testing

In 1980, a group of Wisconsin foresters was selected and trained to use and test the new system. The selection was based on the need to include the entire range of timber types and fire experience in Wisconsin. The training took approximately 2 days and included practice exercises for several hypothetical fires. Each participant was instructed to appraise each fire in his district using both the old and the new system. Each was asked to critically evaluate the system and be prepared to discuss the need for changes and improvements. Revisions were made and testing continued during the 1981 fire season. Final revisions were made and training conducted to implement the system Statewide prior to the 1982 fire season.

The cooperative development of the new Wisconsin appraisal system attempted to strike a balance between a theoretically correct system and one that is practical and easy to use. Testing by field foresters identified practical problems that required revisions and also resulted in streamlining the reporting forms and the instruction guidebook. Most were pleased with the new system and had little difficulty applying it.

SUMMARY

The new system provides a consistent method for appraising the full range of fire-related resource effects. It represents a step forward in the evolution toward complete and theoretically correct State systems and is flexible enough to accommodate changes as more current information becomes available and

as general tables, based on applications of more complex systems over a period of years, are developed for easy use in the field. Although no attempt is made to put dollar figures on some nonmarket values, a well-defined procedure is provided to estimate the relative impact of fire on these resources. Although certain of the inputs required are specific to Wisconsin, such as hunter success indices and timber types or prices, similar data for many other Northeastern States are probably available and the basic format should be generally useful.

The items listed below should be updated periodically or as new information becomes available.

1. **Timber Prices**—New prices can be obtained annually from Wisconsin DNR timber management personnel.

2. **Wildlife Success Indices**—These should be reviewed and updated at two to five year intervals. If the second update shows only minor changes are occurring, subsequent updatings may be unnecessary.

3. **Wildlife Values**—When no new data are available, the value per hunter day for each species should be adjusted annually for inflation using the consumer price index. The adjustment should be in early spring after the consumer price index becomes available but before the fire season begins. New values should be used as they become available in the National Surveys of Hunting, Fishing and Wildlife Associated Recreation published periodically by the U.S. Fish and Wildlife Service.

4. **Ornamental Tree Values**—Values should be adjusted annually for inflation.

5. **Recreation Values**—Values per visitor day for each type of use should be adjusted annually for inflation until new information becomes available.

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A fire effects appraisal system for Wisconsin. Gen. Tech. Rep. NC-90. St. Paul, MN: U.S. Department of Agriculture, Forest Service, North Central Forest Experiment Station; 1983. 8 p.

Describes a new wildfire effects appraisal system developed for Wisconsin.

KEY WORDS: Fire management, economics, fire damage, fire benefits, valuation procedure.